

Moving to California

- After graduating you get a job in Northern California. To move there, you rent a truck for all of your possessions. You also decide to take your car with you by towing it behind the truck. The instructions you get with the truck tells you that the maximum truck weight when fully loaded is 20,000 lbs and that the towing hitch that you rented has a maximum strength of 1000 lbs. Just before you leave, you weigh the fully loaded truck and find it to be 15,000 lbs. At the same time you weigh your car and find it to weigh 3000 lbs. You begin to worry if the hitch is strong enough. Then you remember that you can push your car and can easily keep it moving at a constant velocity. You know that air resistance will increase as the car goes faster but from your experience you estimate that the sum of the forces due to air resistance and friction on the car is not more than 300 lbs. What is the maximum acceleration you can have on your way to California?

Project

- Build a system of wood blocks (3 blocks maximum)
- Draw the system.
- Then draw each block of the system with all of the forces acting on each individual block.

Lesson #40

Topic: Multiple objects and Internal forces

Objectives: (After this class I will be able to)

1. Isolate an individual object located within a system and draw all forces acting on it.
2. Use Newton's third law to identify all of the internal forces of a system consisting of multiple objects.

Warm Up: A 1kg block is at rest on top of a 5kg wood block. What is the weight of each block? What is the normal force acting on each block? Draw a diagram of this system.

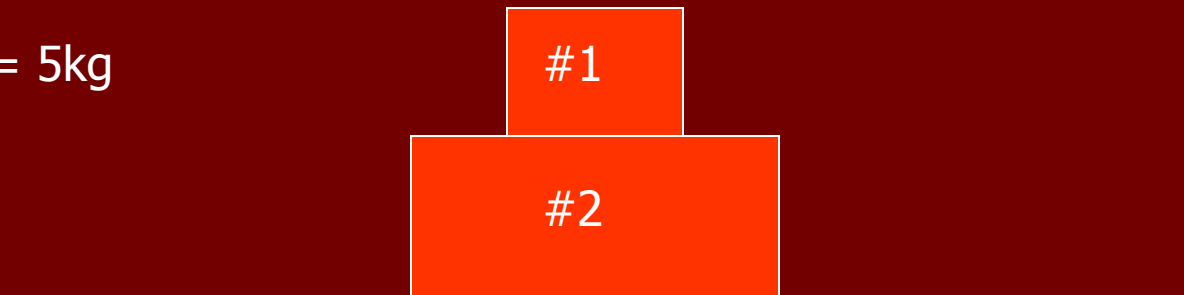
Assignment: "Interaction forces" due tomorrow

Systems

- Systems are used to describe the interaction of forces between multiple objects.

#1: $m = 1\text{kg}$

#2: $m = 5\text{kg}$



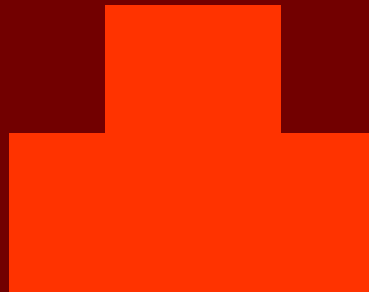
Systems

- Entire systems can be treated as one single object.
- And we can analyze the forces acting on that object.

#1: $m = 1\text{kg}$

#2: $m = 5\text{kg}$

$M_{\text{total}} = 6\text{kg}$



- These are called external or outside forces.

Systems

- We also can look at each object individually.
- Let's start with the forces acting on block #1

#1: $m = 1\text{kg}$

#2: $m = 5\text{kg}$

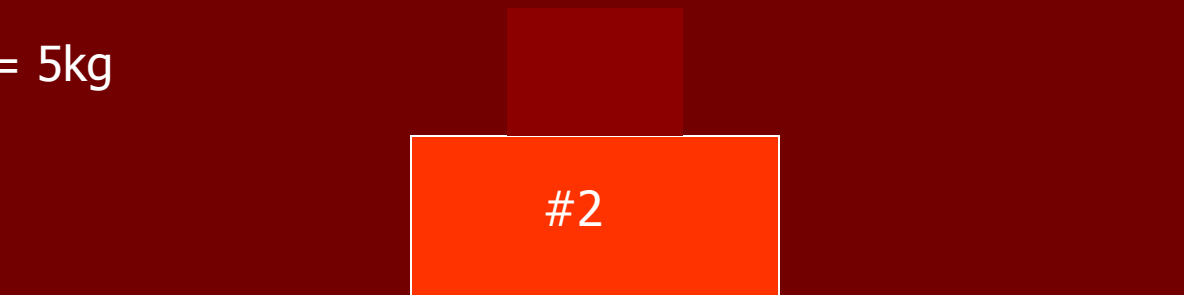


Systems

- Notice that the normal force acting on block #1 is done by block #2, this is an internal force.
- Now let's look at the forces acting on block #2.

#1: $m = 1\text{kg}$

#2: $m = 5\text{kg}$



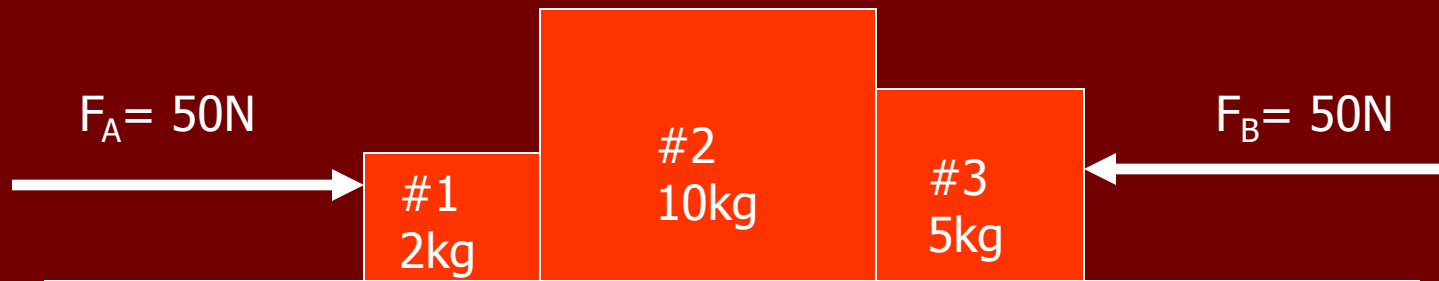
- Notice that block #1 is acting downward on block #2. This is also an internal force.

Internal Forces

- Internal forces are done by one object of the system onto another object of the system.
- Internal forces cannot create a net force (or accelerate) the system.
- Examples: Block #1 acting downward onto block #2, or Block #2 acting upward onto block #1.

System Practice

- For the following system, draw the system as one object and label all of the external forces.
- Then draw each object individually and label the forces acting on it.
- List all the external and internal forces.



- What is the acceleration of the system?

Lesson #41

Topic: Accelerating Systems

Objectives: (After this class I will be able to)

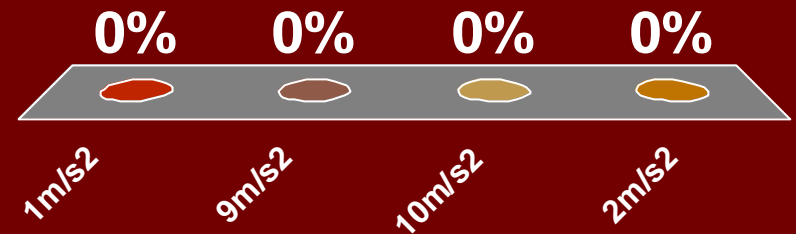
1. Find the acceleration of a system given the net force acting on the system (and vice versa).
2. Use the net force acting on individual objects to solve for unknown internal forces (and vice versa).

Warm Up: A 1kg block, 3kg block, and 5kg block are all side by side at rest on a frictionless table. What is the acceleration of the system when I apply a force of 9N to the side of the 1kg block?

Assignment: "Multiple objects and internal forces" due tomorrow

A 1kg block, 3kg block, and 5kg block are all side by side at rest on a frictionless table. What is the acceleration of the system when I apply a force of 9N to the side of the 1kg block?

1. 1m/s^2
2. 9m/s^2
3. 10m/s^2
4. 2m/s^2



Accelerating Systems

- The first step to these problems is to solve for the acceleration of the entire system.
- This is found by dividing the net force acting on the system by the mass of the system.

$$a = ?$$



Accelerating Systems

- The acceleration of the system will be the acceleration of each object within the system.
- The net force acting on each individual object can be found by multiplying its mass by its acceleration.



$$F_{\text{net } 1} =$$

$$F_{\text{net } 2} =$$

$$F_{\text{net } 3} =$$

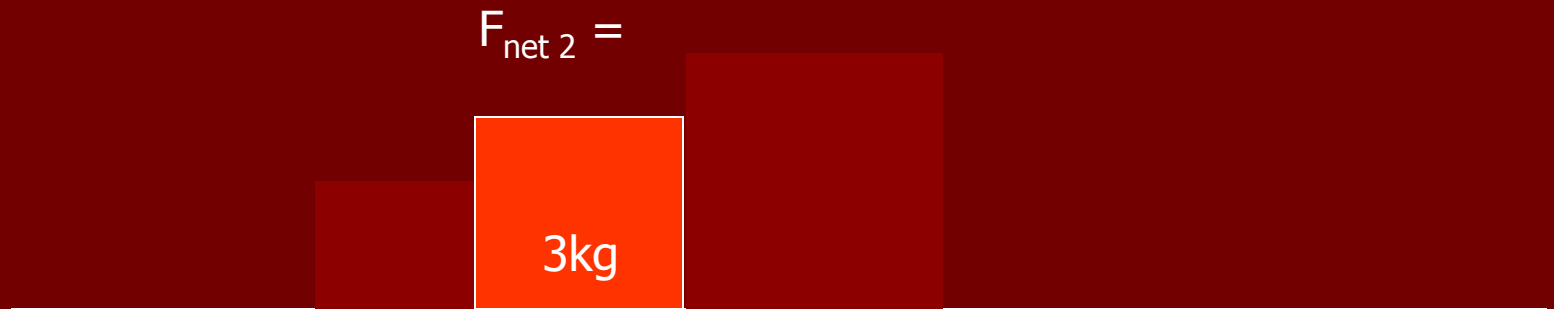
Accelerating Systems

- The net force acting on each individual object can be used to find the internal forces of the system.
- To find the internal forces of the system, you must analyze each object independently.



Accelerating Systems

- Once some internal forces are found, others can be found using Newton's third law.
- Net force equations can be written for each individual object.



Accelerating Systems

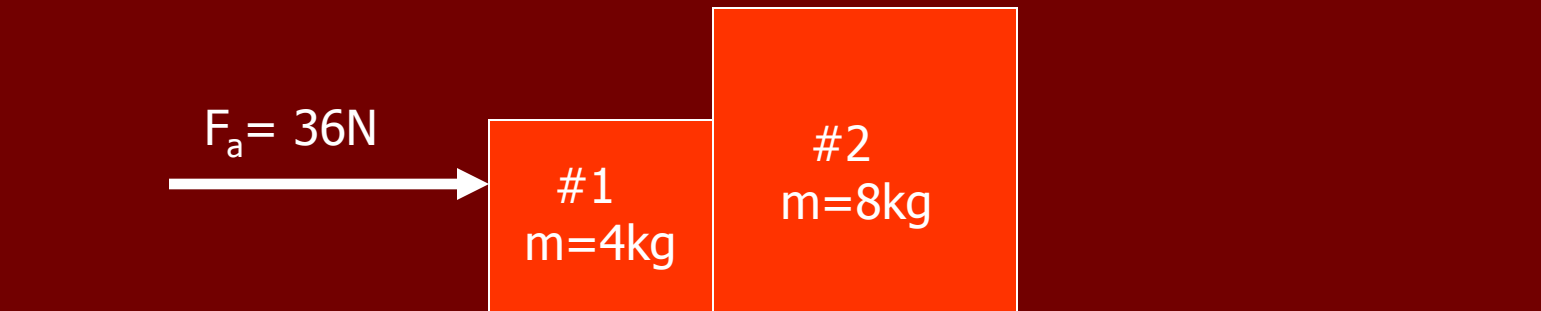
$$F_{\text{net } 3} =$$



5kg

Systems Practice

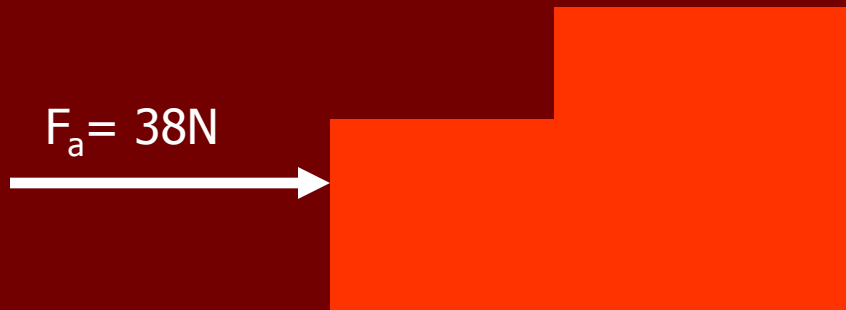
- Find the internal forces acting on the objects within the following system if $\mu = .2$.



Systems Practice

- Find the internal forces acting on the objects within the following system if $\mu = .2$.

$$M_{\text{total}} = 12\text{kg}$$




Systems Practice

- Find the internal forces acting on the objects within the following system if $\mu = .2$.



Systems Practice

- Find the internal forces acting on the objects within the following system if $\mu = .2$.



A diagram showing a red rectangular block resting on a horizontal black line representing a surface. The block is labeled with its mass and a number.

#2
 $m = 8\text{kg}$

Moving to California

- What's the maximum acceleration you can have with your truck towing your car on the way to California?
- Remember to explain your problem solving strategy.